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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

DEVIL'S GARDEN EXTERMINATION PROJECT

PROGRESS REPORT

by

P.C. JOHNSON
Field Aide

Berkeley, California
January 18, 1933

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DEVIL'S GARDEN EXTERMINATION PROJECT

Progress Report

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DEVIL'S GARDEN EXTERMINATION PROJECT

Progress Report

Introduction

The Devil's Garden Extermination Project was begun in fall of 1928, to study the possibilities of complete extermination of the western pine beetle (Dendroctonus brevicomis Lec.) on an isolated area. The area chosen was the Timbered Mountain Unit of the Modoc National Forest. This area, being thus isolated, necessarily involved a study of the flight habits of the beetle. Previous to this time, the only experiments carried on of this nature were the San Joaquin Projects (3, 4).

The area under study covers approximately 62,000 acres, most of which is a very scattered to occasional pine type. Of this, 5,400 acres contains a commercial ponderosa pine stand of approximately 10,000 m.b.m. (1928). The stand is Site 4 and overmature, very little increment having been added in the last few decades.

The experimental area is separated from the nearest ponderosa pine stands by an area of sage and juniper averaging from three to six miles and over in width on the northwest and north, and twenty to thirty miles on the south and east. The accompanying map shows the relationship of the area to these adjacent pine stands. A more complete description of the Devil's Garden area has been given in previous reports, and no further details will be given here.

Nine cruises of the area have been made since 1928. Control operations have been carried on in conjunction with all the cruises except the first. All of these were commercial control operations except those carried on against the 1929-Winter and the 1931-winter broods. The last two might be classed as intensive operations. The cruises of the area have been as follows:

1928 - September
1929 - April, June, August and October
1930 - May and August
1931 - May
1932 - April

Summer control operations were undertaken in 1929 and 1930, but were dropped the following summers. The fire hazard from the burning of the treated trees was too great at that time of year, and the solar heat method was not sufficiently effective.

1931 Control Work

The 1931 infestation was largely dependent upon the success of the control work carried on in the spring of that year, assuming that there was no flight from outside areas. This control was not as successful against the western pine beetle as was hoped, due to the following:

1. Advance flight at time of control (May 13-26) and emergence prior to control
2. Missed spotting
3. Ineffective control work.

There was considerable early emergence in the spring of 1931, due to the mild winter. Much of this emergence had already occurred at the time control work was begun, which accounted for a large number of beetles being in flight during the control. Such beetles were naturally missed.

Four 1931-summer trees were picked up by the spotters at the time of the control, which indicated that the early emergence had already caused new attacks. There were probably other 1931-summer trees which were invisible to the spotters, since the attacks were too new to cause any fading. Along with these new brood trees were those containing only very small broods, either filling in previous attacks or working in the tops and limbs. Such a tree may continue to harbor these small broods for several years with little external evidence of attack, until enough of the tree has been infested to cause its death.

Some of the 1931 spring control was ineffective, due largely to climatic conditions. An early spring made burning very hazardous. The trees cut for treatment were burned at night as a safety measure, and on some trees the elapsed time between cutting and burning was almost a week. This allowed considerable opportunity for emergence and reinfestation, since the majority of the brood was in the advanced stages.

The above factors were probably largely responsible for the heavy 1931 brood of both western pine beetles and flathead beetles.

The habits of the flathead beetles makes control of those insects difficult. Small broods are able to maintain themselves in limbs or on small areas on the trunk of the host tree without causing enough external signs to warrant treating. Such broods, together with the flathead beetles that emerged before control, were missed by the spotters.

1931 Infestation

The 1932 spring survey of the Devil's Garden area was made the latter part of April by the regular field crew of the U.S. Bureau of Entomology with the cooperation of the Forest Service. The greater part of the infestation was centered in the better type of timber, as in former years. The spread was found to be to the east and southwest, the latter scattering for some distance into the marginal type of timber.

The results of the cruise showed 71 infested trees--53 killed by the 1931-winter brood totaling 55,880 board feet, and 18 trees killed and abandoned by the 1931-summer brood with a loss of 27,120 board feet. This brought the 1931 loss to 75 trees with a volume of 83,000 board feet, which was the largest since the project was begun. It is believed, however, that this was exceeded by the 1926 loss, since the peak of a heavy infestation was reached at that time.

The 1931 infestation was confined largely to attacks on overmature trees with intermediate crowns and to suppressed trees of the same age class. The distribution of the various tree classes making up the 1931 infestation is shown below.

Keen's Classes		Dunning's Classes	
Class	No. of Trees	Class	No. of Trees
4C	21	5	30
4D	9	7	10
4B	5	4	6
4A	4	3	4
3A	4	1	2
3B	3	2	1
3C	3		
2A	2		
3D	1		
2B	1		
	53		53

The above distribution might be expected, since the majority of the commercial timber in Devil's Garden is overmature.

1932 Control Work

The 1932 spring control operation was carried out from April 27 to May 11. All the six men making up the crew acted as both spotters and treaters. The cruise of the area lasted three days and was followed immediately by control work. This control, unlike that of 1931, was made under satisfactory climatic conditions. The previous winter had been a severe one and control work was begun before much emergence had occurred. Stem analysis of the treated trees indicated some emergence, but it is believed that most of this occurred late in the fall of 1931. Burning conditions hampered control work during the first week, due to the dampness of the area, but these were improved during the following week by warm weather.

Of the 53 winter-brood trees spotted in the cruise, 52 were treated. The other contained only 90 board feet and was left untreated, as no insects were found in it. This was the first time since the winter brood of 1929 that the volume of timber treated equaled the volume of the brood trees marked in the cruise. No 1932-brood trees were found on the area at that time, which indicated that very little emergence had occurred prior to control.

The infested and treated trees on the area since the beginning of the study are shown in Table 1 and Fig. 1.

Table 1

Volume of Timber Infested and Treated - Devil's Garden Project

Year and Season		Infested			Treated		
		No.Trs.	Volume	Tot.Vol.	No.Trs.	Volume	Tot.Vol.
1927	Summer	34	44,960	77,810			
	Winter	31	32,850				
1928	Summer	15	15,640	64,120			
	Winter	45	48,480		33	34,920	34,920
1929	Summer(standing	14	14,750		4	3,390	
	(trap trees	4	9,930	46,480	4	9,930	35,120
	Winter	20	21,800		20	21,800	
1930	Summer(standing	6	4,230		2	1,460	
	(trap trees	4	3,700	49,990	3	2,520	39,460
	Winter	47	42,060		40	35,480	
1931	Summer	22	27,120	83,000	4	2,240	58,030
	Winter	53	55,880		52	55,790	

The 1932 control work was more effective than that done the previous year, for the following reasons:

1. The work was begun earlier and this, together with a hard winter which delayed the emergence, assured the destruction of almost all the brood;
2. Burning conditions were better, and there was very little if any emergence between the time the trees were cut and when they were burned;
3. Spotting was made easier by the fact that there were no 1932 trees on the area at that time and therefore fewer chances of any brood trees being missed.

The study of abandoned bark surfaces showed that there had been some emergence in the winter-brood trees. As in the 1931 control, this again left a possibility for reinfestation by a very small brood which was not reached by the control. Since the 1932 control was as effective as it could be made, the 1932 brood will be dependent upon the small emergence from the 1931-winter brood trees which occurred before control.

Discussion of Results to Date

Course of Infestation as Compared to Other Areas

In a former report the losses on the Devil's Garden area were compared to those on the Happy Camp-Lava Beds area. It is believed that the latter covers too much territory, both as to size and type. The bulk of the Happy Camp-Lava Beds area is of better site than that of the Devil's Garden area, which would make any comparison of the t[illegible] difficult.

In place of the above comparison, several small areas have been selected which more nearly embody the conditions found in the Devil's Garden area. In selecting such areas the site and past infestation records had to be taken into consideration. Practically all these areas are similar in type to the Devil's Garden, and each contains a sample plot of 320 acres from which past records can be obtained. No control has been done on these areas with the exception of Hog Lake, which was controlled in the winter of 1928-29. The comparison of these with the Devil's Garden area is shown in Table 2 and Fig. 2, all comparisons being made on a per-acre basis.

Table 2

Comparison of Timber Infested in Devil's Garden Area with Areas of Similar Site Conditions

Area	Stand per Acre (1927) B.M.	Losses per Acre (B.M.) 1927 Vol.	1927 % St.	1928 Vol.	1928 % St.	1929 Vol.	1929 % St.	1930 Vol.	1930 % St.	1931 Vol.	1931 % St.
Devil's Garden	4,270*	52	1.2	43	1.0	24	0.6	31	0.7	55	1.3
Hog Lake Sec. 10, T 43 N, R 8 E: Badger Well Res.	12,190	918	7.5	556	4.9	83#	0.8	97	0.9	165	1.6
Sec. 13, T 44 N, R 8 E: Badger Well, Contr. Area:	9,860					81	0.8	80	0.8	196	2.2
Sec. 16, T 44 N, R 8 E: Brown's Well	11,440	998	8.6	628	6.0	56	0.6	67	0.7	299	3.0
Sec. 35, T 44 N, R 8 E: Buck Creek	10,200	472	4.6	1,038	10.7	90	1.0	64	0.7	278	3.3
Ss.8,5, T 46 N, R 15 E:	14,156							102	0.7	256	1.8

*Based on 1,500 acres of commercial type
#Hog Lake Plot subjected to control operations in winter of 1928-29

The Devil's Garden infestation has been consistently lower than that of other areas. The Hog Lake area increased less than the others (excluding Devil's Garden area) during the general rise of beetle activity from 1930 to 1931. There has been a steady increase on almost all the other areas studied since 1929.

Composition of Infestation by Primary Species of Insects

Since the winter of 1928, records have been kept of the bark areas of all treated trees in order to study the insect population of infested trees. These stem analysis records have shown with fair accuracy the amount of infested bark surface attributable to each of the six major forest insects found on the area, the amount of green or uninfested bark surface, and the amount abandoned before control operations.

Table 3 shows the relative amounts of green, infested and abandoned bark surface. The infested bark surface of the trees treated this last spring appears in Table 4 (and Fig. 3), with the amounts killed by the six major species of forest insects.

Table 3
Comparison of Infested, Uninfested and Abandoned Bark Areas on Treated Trees

Year and Season	No. of Records	Green Bark Sq.Ft.	Green Bark %	Infest. Bark Sq.Ft.	Infest. Bark %	Aband. Bark Sq.Ft.	Aband. Bark %	Total Sq.Ft.	Total %
1928-W	33	---	0	8,295	87.0	1,216	13.0	9,509	100
1929-S	4	---	0	1,422	98.7	18	1.3	1,440	100
Trap Trees									
1929-S	4	542	25.6	1,156	54.5	421	19.9	2,119	100
Total									
1929-S	8	542	15.2	2,578	72.5	439	12.3	3,559	100
1929-W	14	120	2.0	5,248	88.6	556	9.4	5,924	100
1930-S	3	---	0	812	82.1	178	17.9	[illegible]	100
Trap Trees									
1930-S	3	---	0	657	74.9	221	25.1	878	100
Total									
1930-S	6	---	0	1,469	78.6	399	21.4	[illegible],868	100
1930-W	40	1,018	7.9	11,254	87.8	551	4.3	12,818	100
1931-S	4	81	3.6	997	44.5	---	0	2,240	100
1931-W	52	2,879	13.4	16,532	76.9	2,080	9.7	21,491	100

Table 4

Comparison of Bark Areas Infested by Different Species of Insects

Year and Season	No. of Records	D. brev. Sq. Ft.	D. brev. %	D. mont. Sq. Ft.	D. mont. %	D. valens Sq. Ft.	D. valens %	Melanophila Sq. Ft.	Melanophila %	Ips emarg. Sq. Ft.	Ips emarg. %	Ips oreg. Sq. Ft.	Ips oreg. %	Total Sq. Ft.	Total %
1928-W	33	5,329	68.7	483	6.2	13	0.1	1,916	18.1	379	4.8	173	2.1	8,293	100
1928-S	4	1,018	71.7	18	1.1	--	0.0	51	3.6	276	19.5	59	4.1	1,422	100
Trap Trees: 1929-S	4	733	63.4	54	4.7	36	3.1	169	14.6	110	9.5	54	4.7	1,156	100
1929-S Total	8	1,751	67.9	72	2.8	36	1.4	220	8.5	386	5.0	113	4.4	2,578	100
1929-W	14	2,800	41.9	370	7.1	42	0.8	2,084	39.7	320	6.1	232	4.4	5,248	100
1930-S	3	372	45.9	88	10.8	--	0.0	298	36.7	---	0.0	54	6.6	812	100
Trap Trees: 1930-S	3	417	63.5	---	0.0	--	0.0	240	36.5	---	0.0	---	0.0	657	100
Total 1930-S	6	789	55.7	88	6.0	--	0.0	538	36.6	---	0.0	54	3.7	1,469	100
1930-W	40	3,129	27.8	416	3.7	113	1.0	6,336	56.3	990	8.8	270	2.4	11,254	100
1931-S	4	324	32.5	137	13.7	13	1.3	435	43.7	25	2.5	63	6.3	997	100
1931-W	52	6,693	40.5	137	0.8	--	0.0	9,434	57.1	154	0.9	114	0.7	16,532	100
	171	22,755	45.1	1,863	3.7	253	0.5	21,721	43.2	2,640	5.2	1,186	2.3	50,418	100

The flathead beetles have become the dominant species on the Devil's Garden since the summer of 1930. A possible explanation of this is to be found in astudy of the abandoned bark areas. The percentage of bark already abandoned, as found in the 1931 overwintering trees during the spring control operation of 1932, is shown as follows by the six primary species:

Dendroctonus brevicomis	11.1%
" monticolae	5.5
" valens	0.0
Melanophila spp.	69.0
Ips emarginatus	6.9
" oregoni	7.5
	100.0%

Of the bark abandoned by the 1931-winter brood previous to spring control, more than six times as much had been killed by flathead beetles as by western pine beetles. This may have been partially due to the fact that the bark infested by the 1931-summer brood of flatheads was almost 50 per cent greater than that infested by D.b.

A situation such as the above, if extended for several years, would have a tendency to build up a flathead infestation, and might also explain the apparently unsuccessful extermination of the western pine beetle. Such emergence prior to control would leave a small brood of insects free to cause new attacks. These attacks would ordinarily be too fresh to cause any fading of the foliage, and therefore would probably be missed by the spotters at the time of control.

From the percentage of bark area killed by each species on the treated trees, a table (Table 5 and Fig. 4) has been drawn up to show the percentage of bark surface killed by each species for the total number of infested trees for each season on the area.

Table 5
Computed Totals of Infested Bark Areas

Season	No. Inf. Trs.	Av. B.A. per Treated Tr. Sq.Ft.	No. Inf. Trs.	Tot. B.A. of Inf. Trees Sq.Ft.	Infested Trees: D. brevi. Sq.Ft.	%	Melanoph. Sq.Ft.	%	Misc. Ins. Sq.Ft.	%
1928-W	33	236	45	10,620	7,296	68.7	1,922	18.1	1,402	13.2
1929-S	8	322	18	5,796	3,935	67.9	493	8.5	1,368	23.6
1929-W	14	375	20	7,500	3,143	41.9	2,978	39.7	1,379	18.4
1930-S	6	245	10	2,450	1,316	53.7	897	36.6	237	9.7
1930-W	40	281	49	13,769	3,828	27.8	7,752	56.3	2,189	15.9
1931-S	4	249	22	5,478	1,780	32.5	2,388	43.6	1,310	23.9
1931-W	52	318	53	16,854	6,826	40.5	9,623	57.1	405	2.4

Flight Habits as Indicated by Reinfestation

A series of photographs have been included in the report to show the results, if any, of beetles flying into the Devil's Garden area from nearby commercial stands of ponderosa pine. The first of these illustrates the isolation of the extermination area. The remainder show the infested trees on the area spotted individually and in their respective locations for each year beginning with 1927. The infestation that year was confined to a comparatively small area, and each succeeding year it spread slightly to the southwest and east. There was no control on the extermination area until the spring of 1929, which may have affected the concentration of the infestation up to that time. It is apparent that new infestation to the northwest, north or northeast could easily be due to beetles flying into the extermination area from the timber stands in those directions. The nearest ponderosa pine in the direction of the spread of infestation is twelve miles to the southwest and from twenty to thirty miles to the south and east.

From this it may be assumed that no attacks have been made by beetles flying into the extermination area from the Blue Mountain or Crowder Flat pine stands, since the marginal band of timber lying on the northwestern and northern boundaries of the Devil's Garden area has remained fairly clean. It is this timber which lies in the direct path of any beetles coming from the outside areas nearby, and which would probably be the first to be attacked.

Summary

Several indications have been brought out as a result of the 1932 spring control, as follows:

1. While the losses due to the 1931 brood were the largest since the project was begun, they are still considerably below the epidemic stage;

2. In comparing the Devil's Garden area with similar areas not controlled, the losses for the former have been consistently lower and have never exceeded 1.3 per cent of the stand;

3. The bark area killed by flatheads continued to be greater than that killed by D.b.;

4. There has been no evidence of beetles flying into the extermination area from surrounding pine stands several miles away;

5. The continued bark beetle activity on the extermination area has come from within the area itself;

6. The infestation on the area has been confined mainly to the best timber type, with very little loss in the marginal type, though spread to the southwest has been into the latter type.

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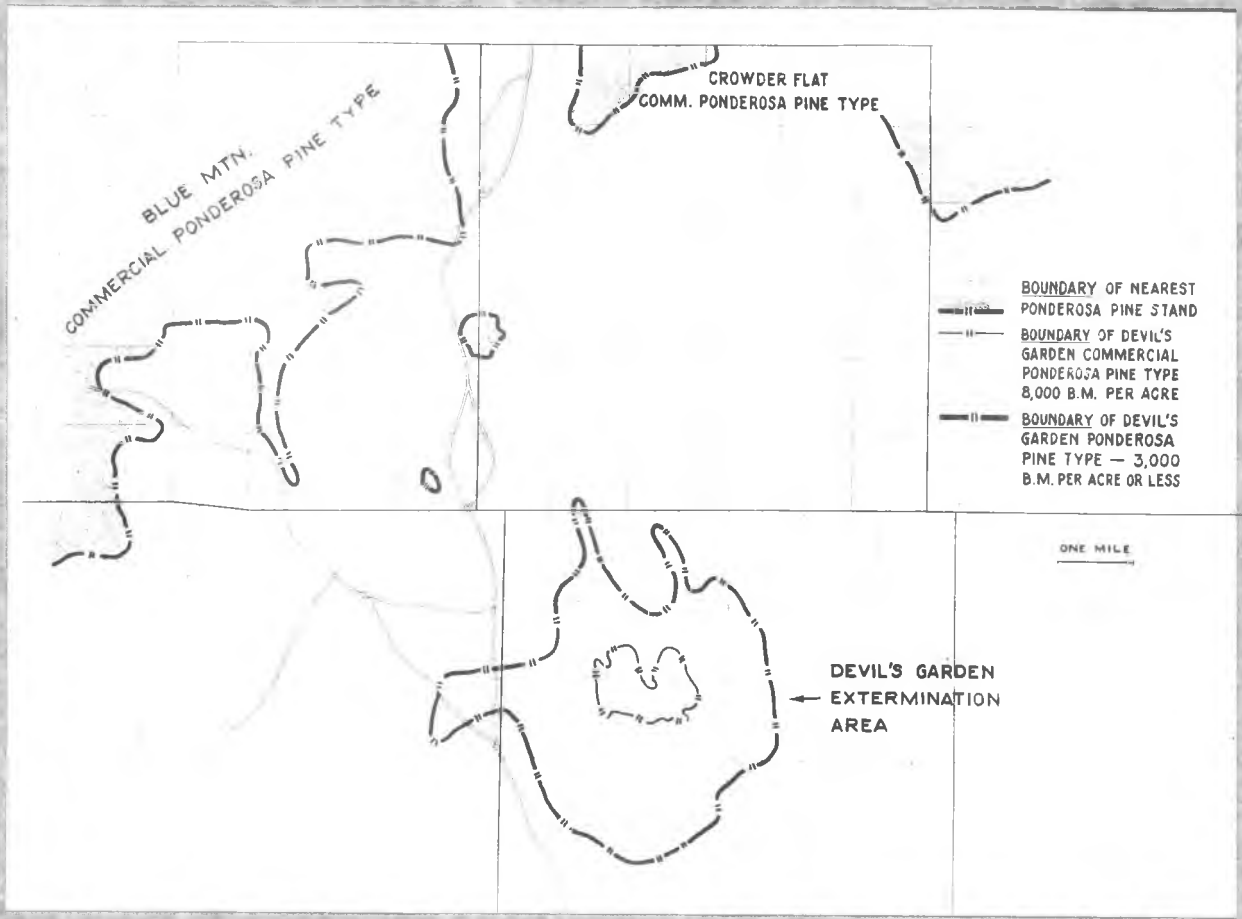
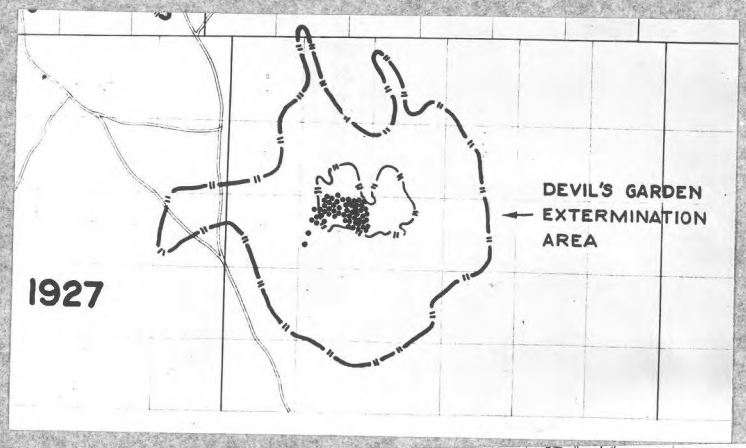
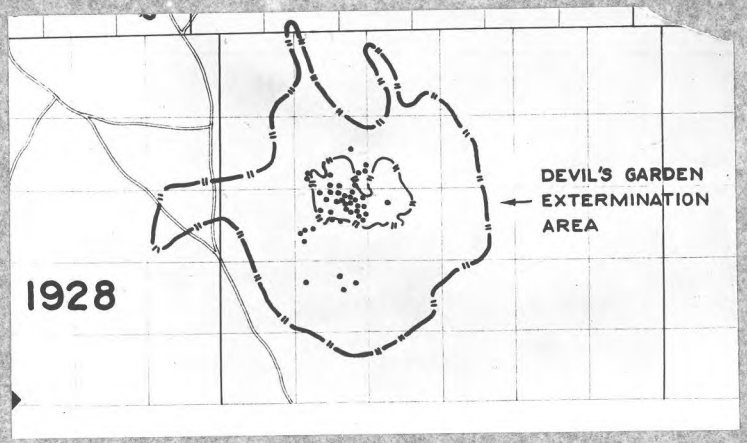

BLUE MTN.
COMMERCIAL PONDEROSA PINE TYPE
CROWDER FLAT
COMM. PONDEROSA PINE TYPE
BOUNDARY OF NEAREST PONDEROSA PINE STAND
BOUNDARY OF DEVIL'S GARDEN COMMERCIAL PONDEROSA PINE TYPE 8,000 B.M. PER ACRE
BOUNDARY OF DEVIL'S GARDEN PONDEROSA PINE TYPE — 3,000 B.M. PER ACRE OR LESS
ONE MILE
DEVIL'S GARDEN EXTERMINATION AREA

The degree of isolation of the Devil's Garden Extermination Area is shown on the above plate. The five on the opposite page indicate the location of infested trees on the project area for the years 1927, 1928, 1929, 1930 and 1931.


1927
DEVIL'S GARDEN
EXTERMINATION
AREA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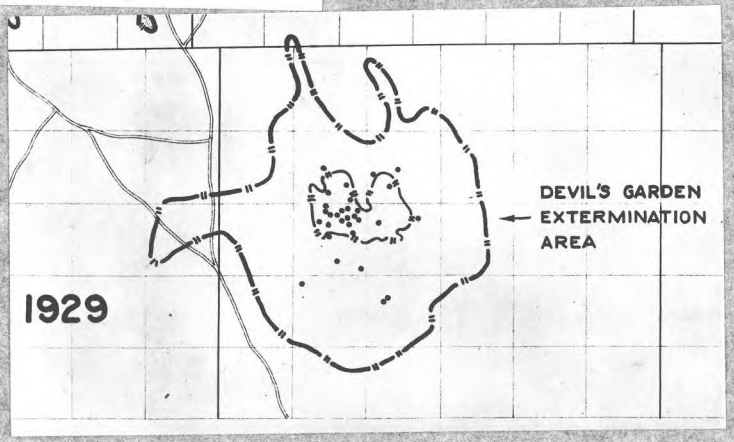
DEVIL'S GARDEN
EXTERMINATION
AREA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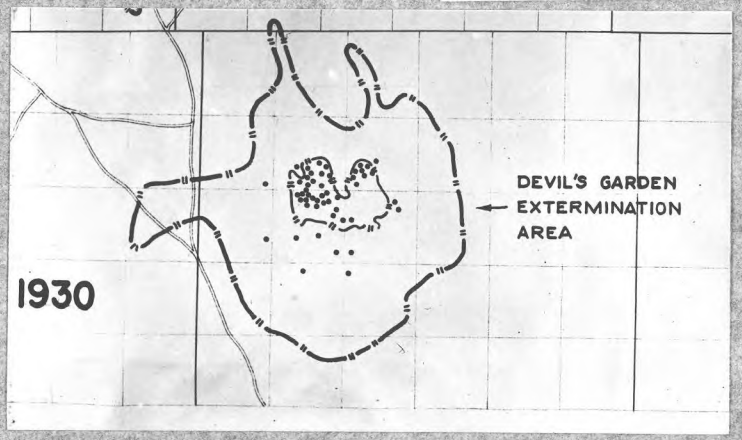
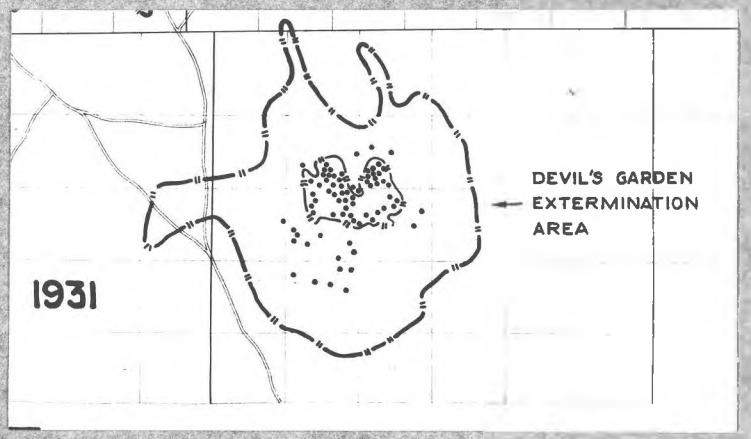
EXTERMINATION
AREA


1930
DEVIL'S GARDEN
EXTERMINATION
AREA


1931
DEVIL'S GARDEN
EXTERMINATION
AREA

VOLUME OF TIMBER INFESTED AND TREATED

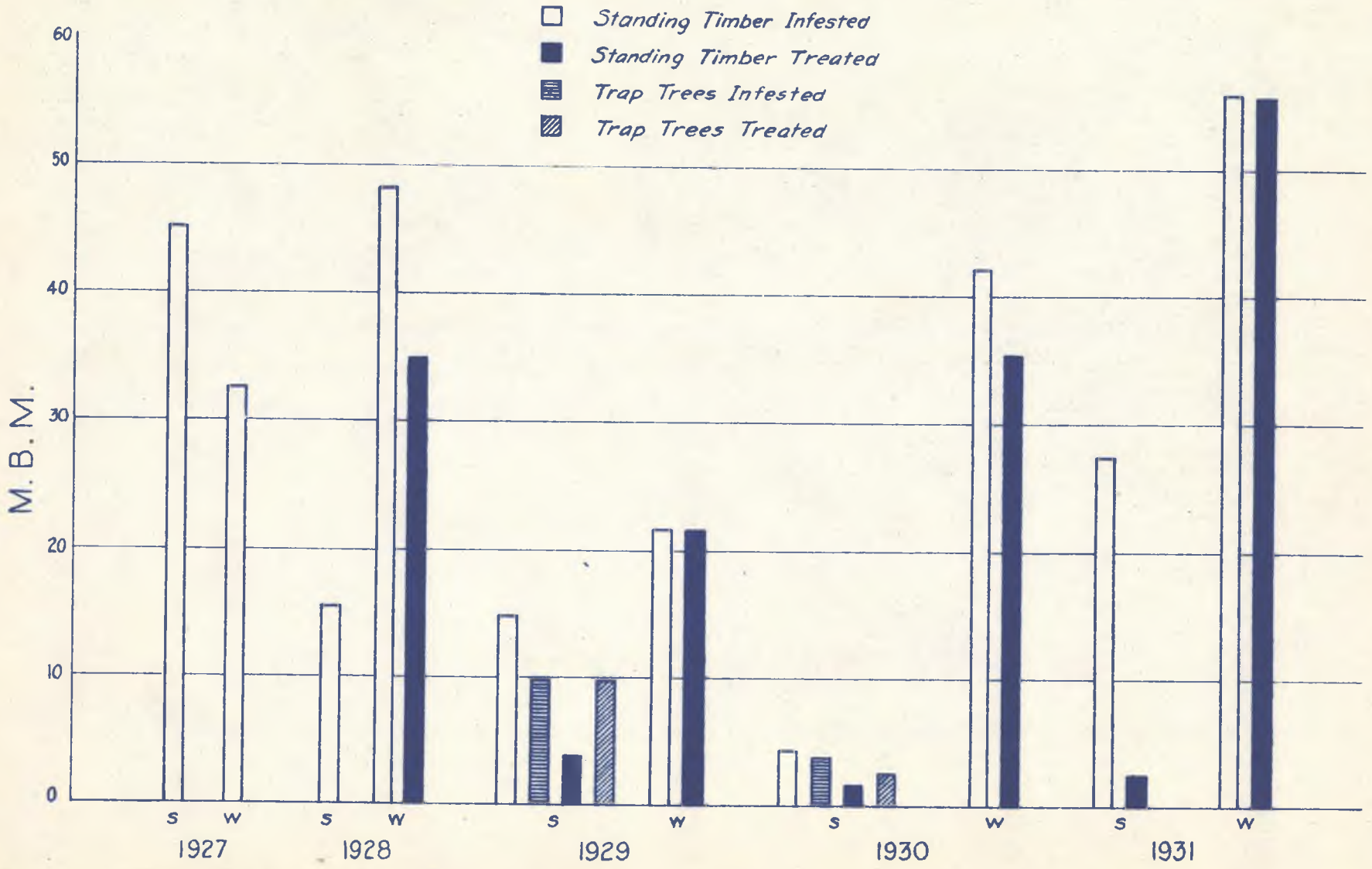
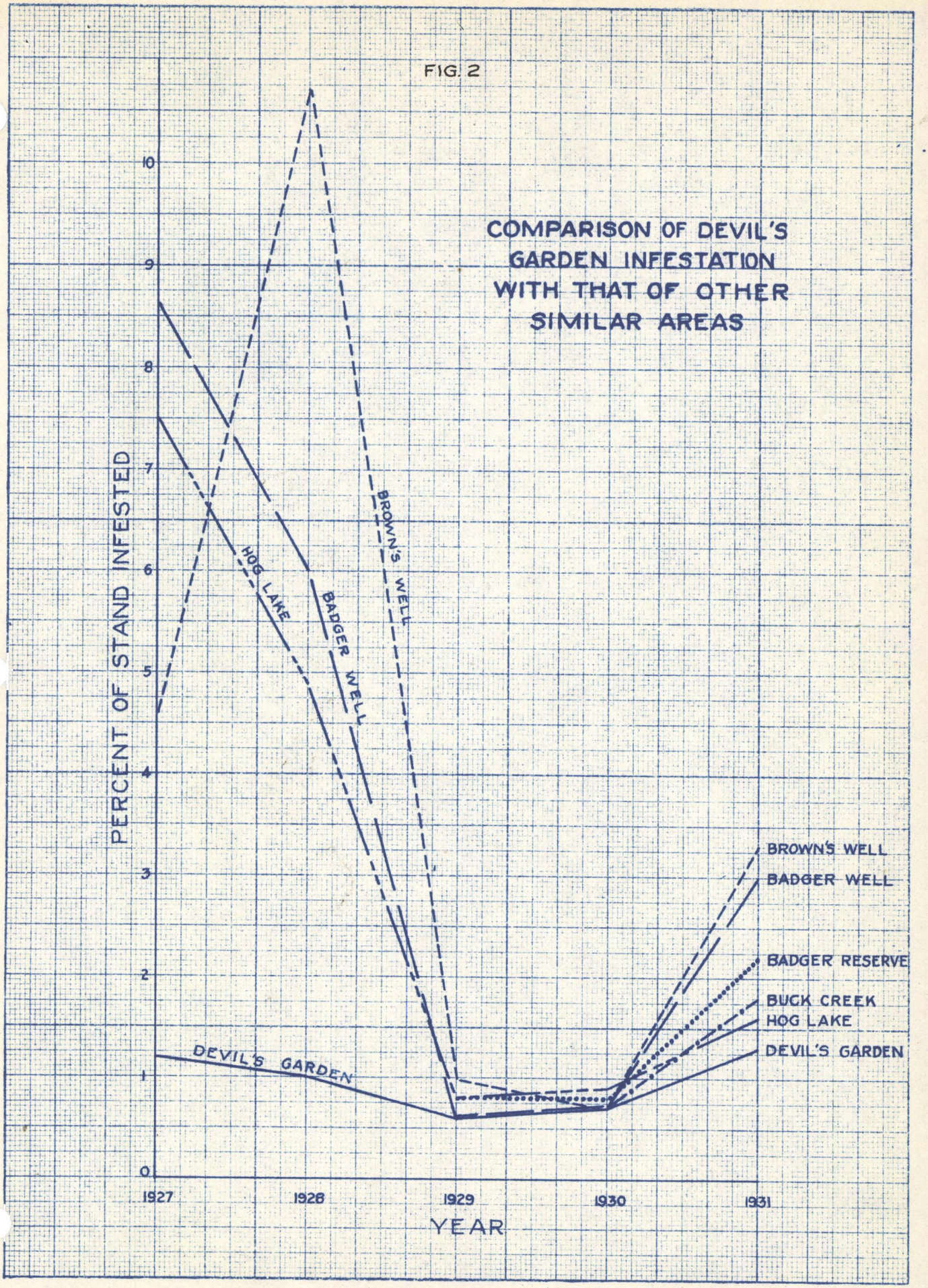


FIG. 1

FIG. 2


COMPARISON OF DEVIL'S GARDEN INFESTATION WITH THAT OF OTHER SIMILAR AREAS
PERCENT OF STAND INFESTED
0
1
2
3
4
5
6
7
8
9
10
1927
1928
1929
1930
1931
YEAR
BROWN'S WELL
BADGER WELL
HOG LAKE
DEVIL'S GARDEN
BROWN'S WELL
BADGER WELL
BADGER RESERVE
BUCK CREEK
HOG LAKE
DEVIL'S GARDEN

K & E CO., N.Y.

FIG. 3

PERCENT OF BARK AREA INFESTED BY SPECIES

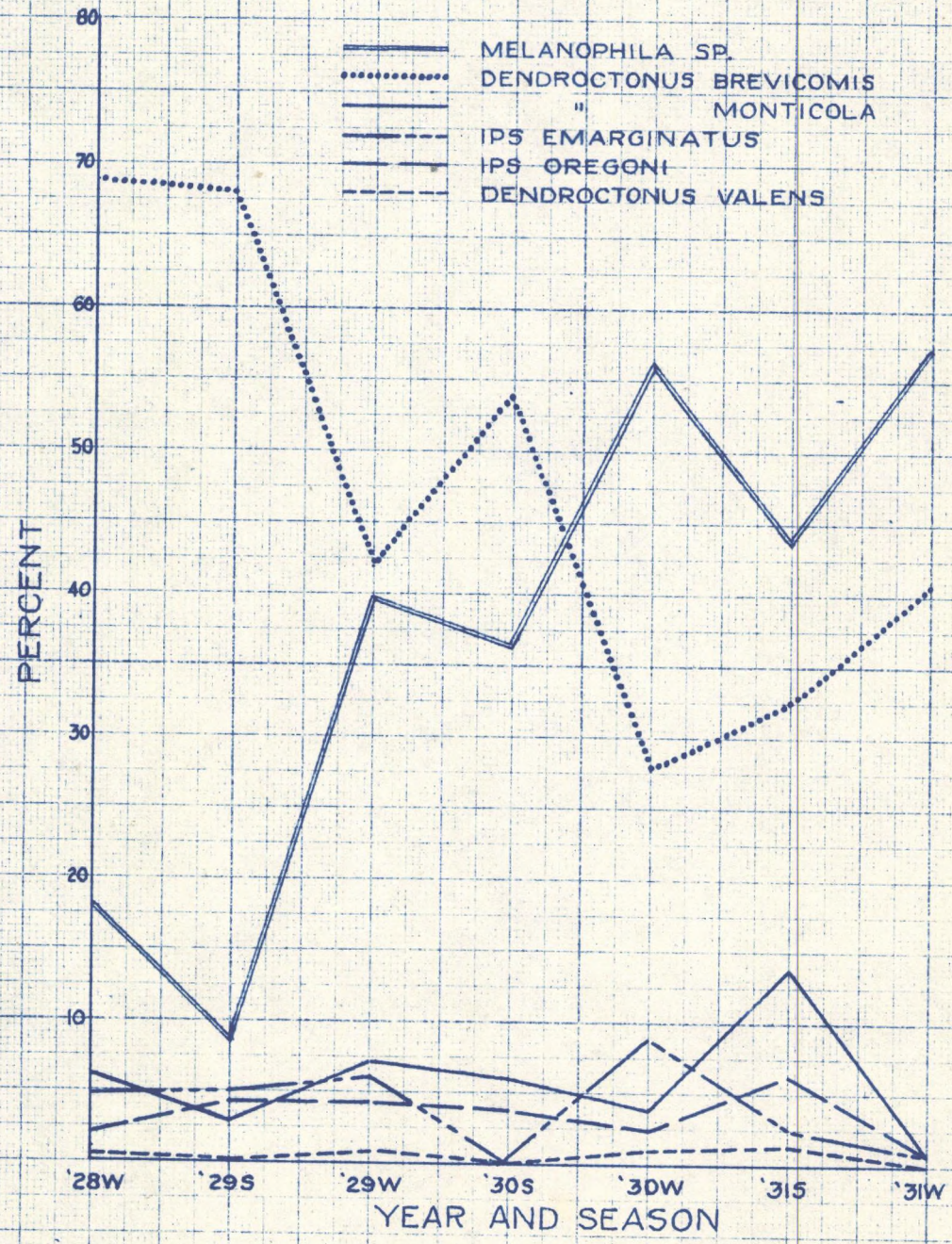
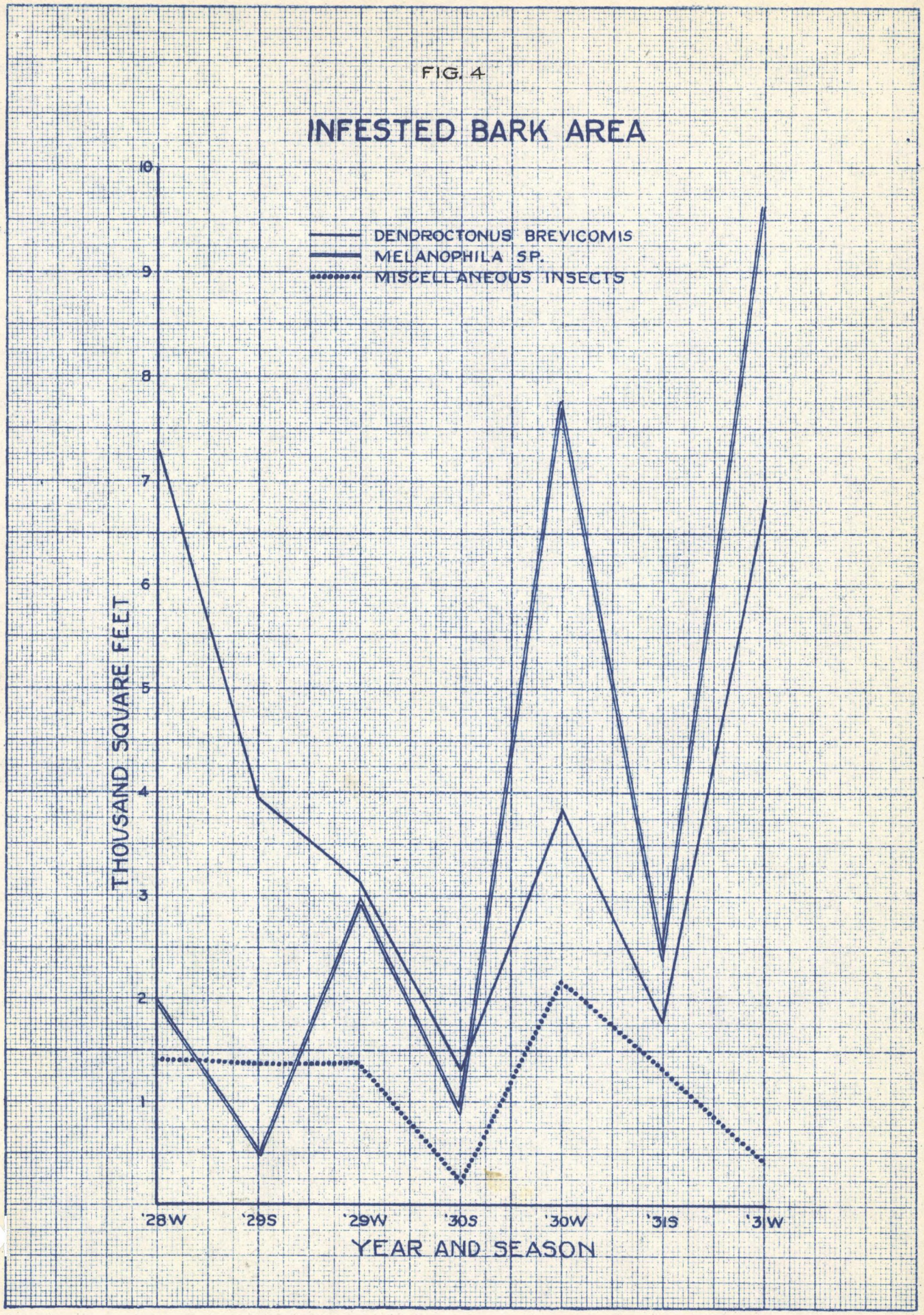


FIG. 4


INFESTED BARK AREA
DENDROCTONUS BREVICOMIS
MELANOPHILA SP.
MISCELLANEOUS INSECTS
THOUSAND SQUARE FEET
10
9
8
7
6
5
4
3
2
1
'28W
'29S
'29W
'30S
'30W
'31S
'31W
YEAR AND SEASON

K & E CO., N. Y.